Dogs have big impacts on soils in city parks

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SUMMARIES!

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Dogs have big impacts on soils in city parks

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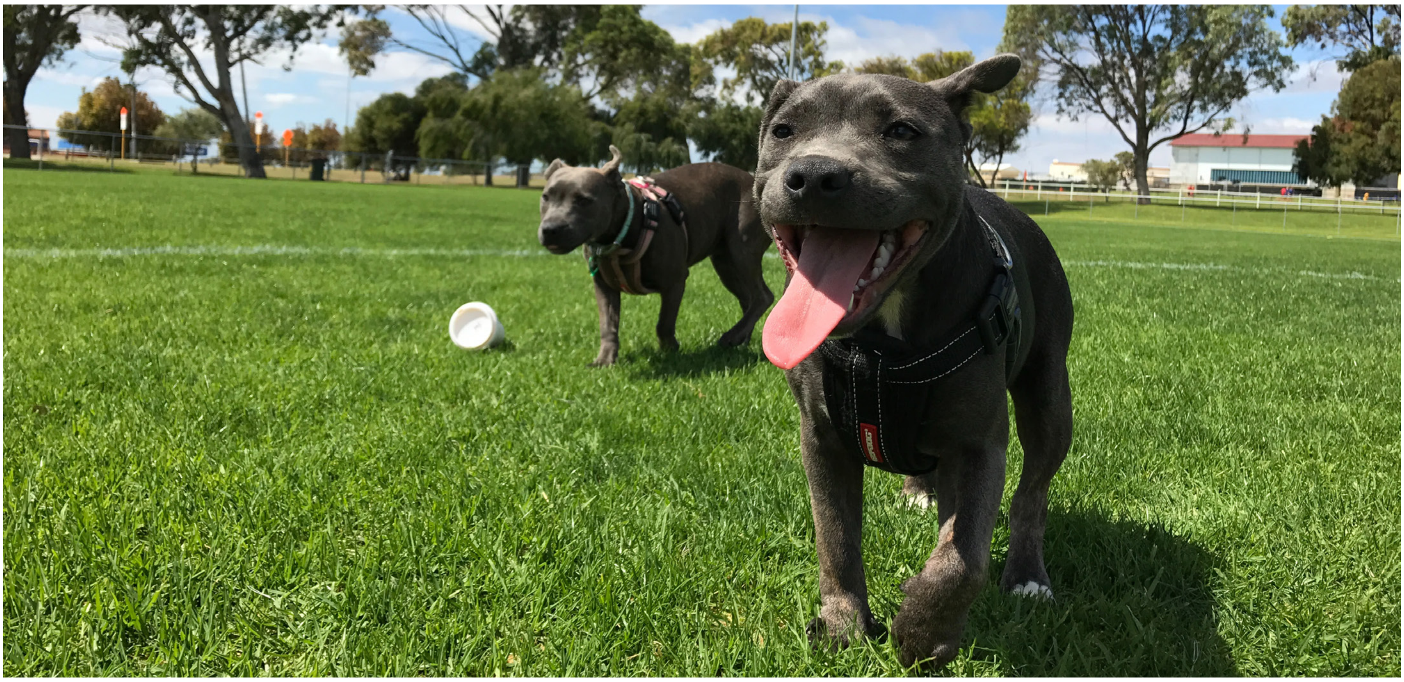

Urban populations and dog ownership are increasing globally, placing urban greenspaces under mounting pressure even as the benefits and services they provide become more important. Dog urine is high in nitrogen (N), an important nutrient, and represents a significant but underappreciated portion of the annual urban N load.

We examined the distribution and impact of dog urine on soils in three types of urban greenspace: Parks, Tree Alleys and Remnant Forests, by collecting and analyzing soil samples from around trees, lampposts and lawn areas near pathways, and comparing these to soils from lawn areas 8 m away from paths.

We found that **soil nitrate, ammonium, total N concentrations and electrical conductivity were significantly higher and soil pH was significantly lower around path-side trees and poles relative to the 8 m lawn plots**. We also found that Tree Alleys were the most impacted of the three greenspace types.

Why does dog urine matter?

Urbanization is on the rise and has widely recognized environmental and ecological impacts (McKinney, 2008; Churkina, 2016; Decina et al., 2019). Along with urbanization, dog ownership is also increasing, and the current pandemic has caused dog adoption rates to soar in many countries (Oppenheim, 2020; Vincent et al., 2020). Recent studies have shown that pet waste is a major source of anthropogenic nitrogen in urban watersheds, and that even short-term applications of **dog urine has serious effects on soil biogeochemistry in green infrastructures** (Hobbie et al. 2017, Lee et al. 2019). Nitrogen (N) is an important nutrient and is often the limiting factor for plant growth and decomposition processes. Excess N may "leak" from terrestrial ecosystems and contribute to algae blooms and eutrophication in surface waters, and to the pollution of groundwater. At the same time, the excess N being deposited by dogs in urban parks and other greenspaces is making them less aesthetically pleasing and may be reducing urban residents' enjoyment of these areas.

In this study, we examined soils from different types of urban greenspace to better understand the spatial distribution of dog-mediated nitrogen deposition (doggy-dep N). Due to leash requirements in Finland (Järjestyslaki, 2003), **we hypothesized that:**

1. **Doggy-dep is not evenly distributed**, with objects located near pathways receiving higher inputs than lawn areas adjacent to the same path. Furthermore, doggy-dep effects will be higher closer to these objects than further away, due to the preference of dogs to countermark the urine of other dogs (Lisberg and Snowdon, 2011).

2. **The magnitude of doggy-dep along pathways will vary by greenspace type**, with Remnant Forests being more heavily impacted than Tree Alleys and Parks the least. We think Remnant Forests will show the highest impact due to leash requirements and the presence of understory vegetation and closely spaced trees bounding the paths, making excursions away from the path more difficult, and so dogs will spend more time on the paths relative to the Tree Alleys and Parks. We expect Tree Alley paths to be more impacted than Park paths due to their linear nature, while the open lawns and widely spaced trees of Parks offer dogs and their owners ample opportunities to deviate from the pathways.

Method

Study Area

We looked at a total of 34 greenspaces in Helsinki and Lahti, Finland, grouped into three typologies: Parks (n = 11), Tree alleys (n = 11) and Remnant forests (n = 12). An interactive version of the field site map can be found at https://bit.ly/3lQcrNq.

Sample collection and analyses

During the summer 2018 we collected composite soil samples from the top 10 cm of soil at three different treatments at each site: 1) a deciduous tree (Acer, Tilia, Ulmus, Betula or Quercus sp.), 2) a lamppost, and 3) a lawn area. At trees and poles, one sample was taken from within 30 cm around the item and a second 1 m away from the item. From the lawn, one sample was taken from within a 0.5 m2 area adjacent to the path, and the second 1 m from the path edge. In Parks we also collected soil samples from lawns >8 m away from pathways.

We measured electrical conductivity (EC), pH, organic matter (OM), nitrate, ammonium and total N concentrations for each sample, as well as δ 15N from a small subset of the samples. All statistical analyses were performed in R (v 3.6.3) (R Core Team, 2020) using generalized linear mixed models (GLMM) (Bates et al., 2015) for all the measured parameters, except for the isotope data, for which we used the Welch two sample t-test.

Main findings

We show that **doggy-dep N in urban greenspaces is highly localized and significantly impacts soil chemistry**, which was found to vary greatly with proximity to path-side trees and poles. However, we found that path-side lawn areas did not differ significantly from the lawn areas 8 m away from the path. This indicates that **path-side trees and poles act as focal points for dog-deposition, but lawn areas do not**, probably due to gender-specific differences in dogs' urinating and scent-marking behaviors (countermarking) (Pal, 2003; Lisberg and Snowdon, 2011). Furthermore, stable isotope analysis showed the soils around path-side trees and poles (n = 6) to have a mean δ15N value of 8.3, while samples taken from 8 m away (n = 4) had a mean δ15N value of 3.5 (t = 3.556, p = 0.008), indicating that the N in these areas originated from different sources.

We found differences between greenspace typologies, but not how we expected. **Remnant forests were found to be the least affected**, while Tree alleys showed the greatest level of impact, followed by Parks. The lower values observed in Remnant Forests could be due to fewer dog walkers in these areas, while Tree Alleys may experience more traffic and may also be the first area of greenspace a dog encounters when being taken outside. Another important factor is the population density of the area around the greenspace. While we didn't directly address this in our study, we did select our sites to be within the urban core or within 500 m of high-density residential areas.

What this means for urban greenspaces

Our study suggest that **the impact of dog urine in urban greenspaces is even greater** than those observed in Lee et al.'s 2019 laboratory study. We also want to stress that doggy-dep is chronic, and multiple dogs will likely urinate in the same location each day. This sustained input of concentrated N in areas frequented by humans represents a uniquely urban phenomenon, one whose closest analogue in terms of soil chemistry may be the confined animal feeding operations (CAFOs) of industrial agriculture. In fact, the average concentrations of ammonium we measured from soils around path-side poles in Parks was 103.9 ± 18.4 mg kg-1 (mean ± SE), which **is more than four times the proposed cleanup standard** (25 mg kg-1) in soil underneath CAFOs in Kansas, USA (Volland et al. 2003).

Compared to natural areas, cities are enriched with N, and while regulations have decreased atmospheric N deposition rates in recent decades (Eshleman et al., 2013), dog ownership is increasing. If current trends continue, the impacts we observed will likely increase in severity, and **doggy-dep could become the largest source of N in cities**.

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Allen, J.A., Setälä, H.M. and Kotze, D.J., 2020. Dog urine has acute impacts on soil chemistry in urban greenspace. Frontiers in Ecology and Evolution, 8, p.463. DOI: 10.3389/fevo.2020.615979

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